

A Work Project, presented as part of the requirements for the Award of a Masters Degree in Economics from the NOVA – School of Business and Economics.

Fiscal Policy under Financial Stress: A Threshold VAR Approach

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A Project carried out on the Macroeconometrics course, under the supervision of:

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Abstract

Title: Fiscal Policy under Financial Stress: A Threshold VAR Approach

The purpose of the project is to measure the impact of fiscal policy on the Portuguese GDP and how it may vary according to the state of the financial market. A Threshold VAR model is presented in which the two regimes are found using a financial stress index that divides the economy into a situation of financial stress and financial stability.

- Threshold VAR
- Financial Stress Index (FSI)
- Fiscal multipliers
- Regime switches

Introduction

Since the beginning of the recent economic and sovereign debt crisis there has been a lot of speculation on what measures governments should implement in order to deal with such phenomenon. All over Europe sovereign states have been implementing austerity packages, focused on government expenditure reductions and increased taxation. In the case of Portugal the packages have been implemented with the help of European and international institutions.

In the current context arises the question of what should be the mix of government actions that best deals with the situation, since monetary policy is now at the European level, individual countries have been focusing in fiscal policies.

The purpose of this project is to analyze the effects of fiscal policy on GDP and how such effects may differ depending on whether we are in a time of financial stability or stress.

To model the financial state of the economy a financial stress index (FSI) was constructed based on key variables and indicators in the financial market, more specifically indicators for bank stress, exchange rate volatility, securities market stress and interest rate stability, in line with Cardarelli et al (2009).

Following a recent line in the literature fiscal multipliers were estimated using a Threshold Vector Autoregressive model that changes states depending on whether the transition variable (FSI) value is higher or lower than a certain threshold.

Business Cycle theories often relies on shocks and propagation mechanisms to explain the length and magnitude of business cycles (i.e. economic fluctuations), one important

theory is the one by Bernanke and Gertler (1989) that relies on capital market imperfections to explain how a financial shock can impact the economy and the business cycle.

It is mainly believed that one important trigger factor of the current economic crisis was the shock in the US financial market. Since financial markets worldwide are highly dependent and correlated it is reasonable to assume that the 2007 financial crisis effect should be able to be seen in the financial stress index (FSI) constructed for the Portuguese economy.

In addition we study the impact of shocks in government controlled variables by constructing generalized impulse response functions (GIRF's) and computing regime dependent fiscal multipliers. The main purpose is to understand the effects of fiscal policy on the overall economic activity and to how financial market conditions might affect government action.

The structure is presented as follows, the first section gives a revision of previous work on VAR based fiscal multipliers, then the model employed is explained and finally the GIRF's and multipliers are presented together with some concluding remarks.

Literature review

The paper by Blanchard and Perotti (2002) introduced a new path in fiscal multipliers empirics. The authors used a Structural VAR model to study the main effects of a shock in government expenditure and taxes on economic activity, using an identification approach based on institutional information and elasticity of fiscal variables.

The results show that a positive shock in government spending has a positive effect in output and a positive tax shock has a negative impact in output, however the size of multipliers are found to be relatively small.

Regarding studies focused in the Portuguese economy, there is one by Afonso and Sousa (2009) in which a Bayesian Structural VAR approach is used. It is found that by imposing a restriction for the government debt dynamics a positive government spending shock has a negative impact in real GDP and the same happens for a positive government revenues shock.

Pereira and Wemans (2013) computed the different impact of non-aggregated fiscal variables in the economy, by breaking the government revenues series into direct and indirect taxes and transfers and the government consumption into compensation to employees and expenditure in goods and services. Detailed results of the fiscal policy impact in the Portuguese GDP can be found in table 1 bellow.

Table1- Impact of fiscal shocks on GDP for the Portuguese Economy

		Shock to taxes			Shock to government expenditure	
		Direct taxes	Indirect taxes	Social transfers	Government Consumption	Goods and services
Pereira and Wemans (2013) 1997q1 : 2007q4 SVAR BP identification	Contemporaneous shock (1euro)	0,0	0,2	0,4	0,1	0,0
	1 year cumulative multipliers (1 euro)	-1,2	-0,2	0,6	0,2	-0,3
Afonso et al (2009) 1995q1 : 2011q3 SVAR BP identification	Positive shock (1%)	0,06%			-0,10%	

More recently empirical studies have been using threshold VAR models to distinguish between periods of recession and expansion and to understand how changes in fiscal variables can affect GDP depending on the initial state of the model.

One important aspect is the choice of what threshold variable to use; it can be either endogenous or exogenous to the VAR model. The most common choices, found in the literature, are output gap, GDP growth, financial stress index or the debt-to-GDP ratio.

The TVAR literature is recent, however the studies in the field show, consistently, that the non-linearity obtained by using regime switching models is corroborated by non-linearity tests and, in fact, it is found to exist a significant difference on the impact of a fiscal shock depending on the state of the economy.

Since the present study is about fiscal policy under financial instability it is useful to present the study by Afonso et al (2011), which uses a financial stress index to measure financial stress under a Threshold VAR framework. The main conclusions are that the response of economic growth to a fiscal shock is mostly positive in both a regime of financial stress or stability. Financial stress worsens the fiscal position of a country and finally the size of the fiscal multipliers is higher than average during the current crisis in all countries, except in the UK.

In a related study Ferraresi et al (2013) investigate the impact of fiscal policies across credit regimes, using the spread of BAA corporate bond yield and 10-year T-bill rate as a proxy for credit conditions. It is found that the impact of fiscal shocks in output is stronger under a tight credit regime and also fiscal multipliers are more persistent.

Ehlers (2011) uses the TED spread as a proxy for financial market conditions in the US to show how such conditions change the transmission mechanism in the economy and differ depending on the regime.

The next section presents an explanation of the methodology and variables used in the threshold VAR model.

The Model

The threshold vector auto-regressive model is specified using an endogenous transition variable (FSI). These type of models allow to capture non-linear dynamics between variables, since they let shocks depend on the initial condition of the economy (i.e. in what regime the economy is in at the time of the fiscal shock) and so, also allow to account for the different responses that output can have depending on the initial situation.

The Threshold VAR model:

$$Y_t = I_{(S_{t-d} < \gamma)} [A^1 Y_t + B^1(L) Y_{t-1}] + I_{(S_{t-d} \geq \gamma)} [A^2 Y_t + B^2(L) Y_{t-1}] + u_t$$

In which Y_t is a four dimension vector $[y_t \ g_t \ t_t \ s_t]'$ where y_t real GDP, g_t is represents total government expenditures, t_t total net taxes and s_t is the financial stress index. $I_{(S_{t-d} < \gamma)}$ is the indicator function that takes the value of one when the threshold variable (S_{t-d}) is smaller than a certain value (γ) and zero when is higher or equal. Finally the parameter d corresponds to the lag delay of the threshold variable and A^i and $B^i(L)$ are lag polynomial matrices.

In this model the threshold variable will be the index for financial stress, meaning that the model will have two regimes one for a situation of financial stress (when S_{t-1} exceeds a certain value) and for a situation of financial soundness.

The error term u_t is a vector of uncorrelated disturbances (error terms) with mean zero and covariance matrix of $\sum u$.

For the identification procedure there are three main choices in the literature, the identification approach by Blanchard and Perotti (2002), the identification procedure of Romer and Romer (2007) and finally a simple Cholesky decomposition.

For the purpose of the study a Cholesky identification was chosen in order to simplify the computation, following the methodology of Batini et al (2012). The ordering employed is the following: GDP, government expenditures, net taxes and FSI.

The data

The study uses quarterly data for the Portuguese economy, from 1991Q1 to 2013Q4, comprising 93 observations. Following Blanchard and Perotti (2002) definitions, government expenditures are the summation of total current government expenditures and total capital expenditure. Net taxes are defined as total government revenues minus transferences (including interest payments). Both series were directly taken from the Banco de Portugal data warehouse and were seasonally adjusted using the X-12 method.

The real GDP was taken from OECD statistics and represents volume estimates with 2005 as base year (seasonal adjustments were made at the origin using the method X-12 ARIMA). All the three variables are expressed in millions of Euros.

The descriptive statics and graphs of the variables employed in the model can be found in appendix 1 and 2.

The financial stress index described below was the last variable included in the model and is also used as the threshold parameter where its lag delay (d) is set to be one, since we are assuming the economy takes one quarter to adjust to changes in the variable.

The assumption is also realistic when considering that if a shock happens in the financial market it will take some time for agents to perceive the its effects and it is reasonable to assume the adjustment will only occur in the next quarter, due to the information lag.

The threshold value was computed using a grid search (appendix 3) that minimized the sum of square residuals and was found to be approximately 23,32, separating the economy in the two regimes. The periods of financial stress correspond well to historical events.

The next step is to analyze the stationarity of the variables, for this purpose, the Augmented Dickey Fuller (appendix 4) test was used and it was concluded that real GDP, government expenditure and net taxes should be taken in log and first differences, so to become stationary.

According to the Schwarz information criteria, presented in annex 5, the number of lags included in the TVAR is one, also following the line in majority of the relevant literature.

Finally it is also important to verify if the data fits the non-linearity of the threshold VAR model, for that a likelihood ratio test was done, testing a linear VAR model against the alternative hypothesis of a TVAR model. The LR test output is presented in the appendix 6 and the null hypothesis is rejected for all significance level, hence it is possible to conclude that, in fact, the model fits better the data and its non-linearity structure.

Financial Stress Index (FSI)

Since the aim of the study is to measure the impact of government fiscal policy and how it differs according to the existing financial conditions, the FSI was constructed and used as threshold variable in the model.

The FSI is defined as the sum of six variables, which act as a proxy for stress in the financial market, following the approach proposed by Cardarelli, et al (2009) and adapted for the Portuguese economy.

The first variable used is the exchange rate volatility, using the real effective exchange rate measured in monthly percentage change, measured using a GARCH(1,1) model.

For the stock market stress two variables were used, the stock decline and the time varying stock volatility. The stock decline was calculated through the formula:

$\frac{Share\ Price_{t-1} - Share\ Price_t}{Share\ Price_{t-1}}$ and the stock volatility modeled using a GARCH(1,1) model.

Both variables were computed using the share price index.

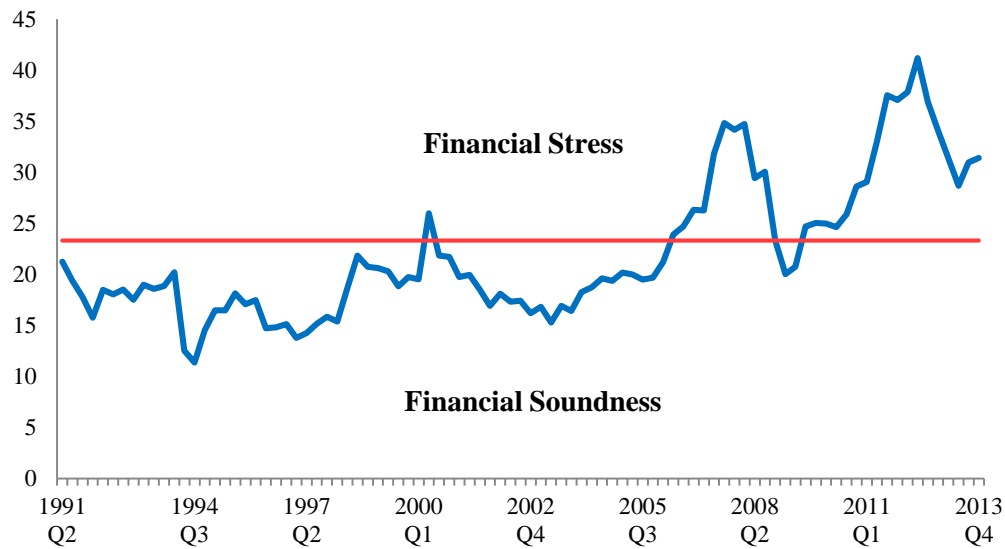
For the banking sector it was used the European banking sector beta, as a measure of risk in the banking sector. The other variable used was the inverted term structure, defined as the difference between the short-term and long-term Portuguese government interest rate.

The last variable used is the spread between Portuguese and German long-term government bonds, for a measure of both government debt burden and interest rate instability.

The spread between Portuguese and German bond was included mainly because it represents the difficulty of government financing, especially during the crisis and before

entering to the Eurozone. The variable is likely to have an impact in overall financial market condition since it influences the expectations of economic and market agents. It also acts as a proxy for financial market conditions.

Graph 1 | Financial Stress Index



Finally the interpretation of the index, presented in graph 1, is very straight forward, in times of higher stress and instability in markets the value of the index is higher and in times of financial soundness the index has typically lower values.

Having this in mind when using the FSI as transition variable in the threshold VAR model, periods of high stress in the financial market can be easily specified as a period in which the index is above the 23.32 threshold, comprising years consistent with the periods identified to be crisis or times of financial instability.

In conclusion the aim of the study is to measure the impact of government fiscal policy and how it differs according to the existing financial conditions, this is the reason to why the FSI was constructed and used as threshold variable in the model.

Estimation results

The threshold VAR model computed can be found in the appendix 7 and it is possible to verify that financial stress (S) has a negative impact on GDP. During situations of financial stress output is likely to be smaller because of this negative correlation.

Last quarter government spending has an initial direct negative impact on GDP for both regimes and net taxes only have a negative direct impact when under financial stress.

Generalized Impulse Response Functions

Impulse response functions typically measure the impact that a shock in one variable has in all the variables in the model, its propagation and persistency as time goes by. They are very useful to measure the impact of government fiscal policy in the economy and are typically employed in these type of studies.

Due to the non-linear structure of the threshold VAR model it is not possible to rely on the moving average transformation to compute the usual impulse response functions. The Koop et al (1996) methodology, followed in this section, proposes the generalized impulse response functions (GIRFs) framework. The formula employed to compute the impulse response functions is the following:

$$GIRF_{t+k} = E[Y_{t+k}|\Omega_{t-1}; \delta] - E[Y_{t+k}|\Omega_{t-1}]$$

Where Ω_{t-1} is the realized history, comprising all the variables in the model, δ represents the shocks and is measured in standard deviation units.

One important feature of the computed GIRFs is that they will allow for endogenous regime switches, meaning that due to a shock it will be possible to change regime at some point in time.

The sample was divided into the two regimes, then it was chosen a period for financial stability (from 2001Q3 to 2005Q4) and a period of financial stress (from 2009Q3 to 2013Q4) identified has to be below or above the threshold value of 23.32.

The impulse response functions shows the impact that a shock to taxes or government spending has in output. Since our model uses the variables in first differences of the logarithm, we can interpret the values given by the model estimation as growth rates.

By definition, they measure the average impact of a given shock taking into account the expected growth rate of output and the variables history, and can be interpreted as the perceptual change in the growth rate of output solely due to the shock at period t and its propagation across the periods that follow.

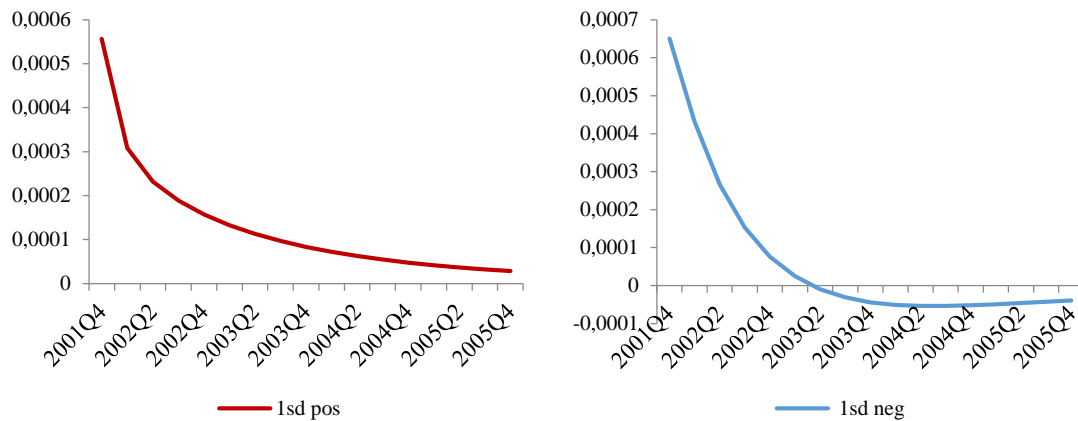
Focusing now on the graphic analysis, the GIRF's results will give some important conclusions on the effects of fiscal policy on the Portuguese economy.

Starting in a situation of financial stability, a positive government spending shock, at the third quarter of 2001, has an initial positive impact on the output growth rate. The impact of the shock is slowly fading over time, meaning that GDP is increasing at a smaller rate trough time.

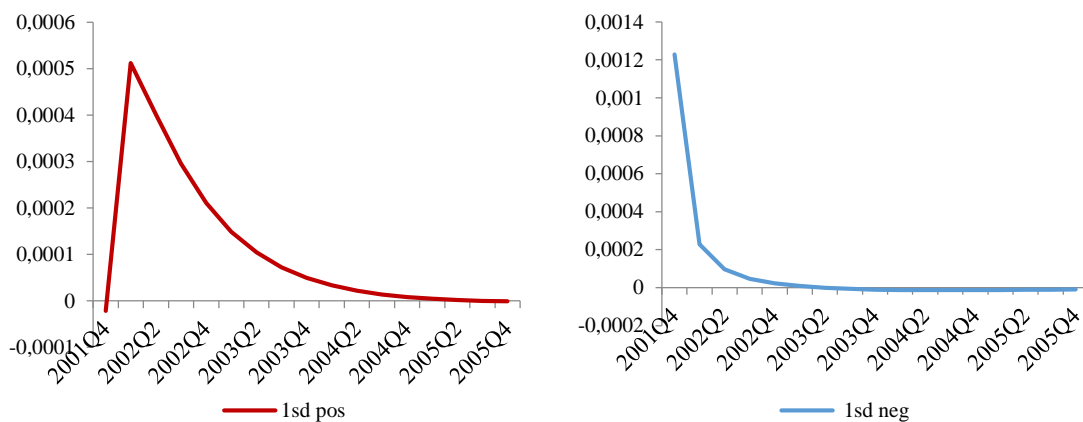
However a negative government expenditure shock also has an immediate positive effect in the output growth rate. After eight quarters the growth becomes negative,

which implies that the long run effect of a decrease in government spending becomes negative.

Graph 2 | Government spending shock effect on output growth rate (Financial stability)



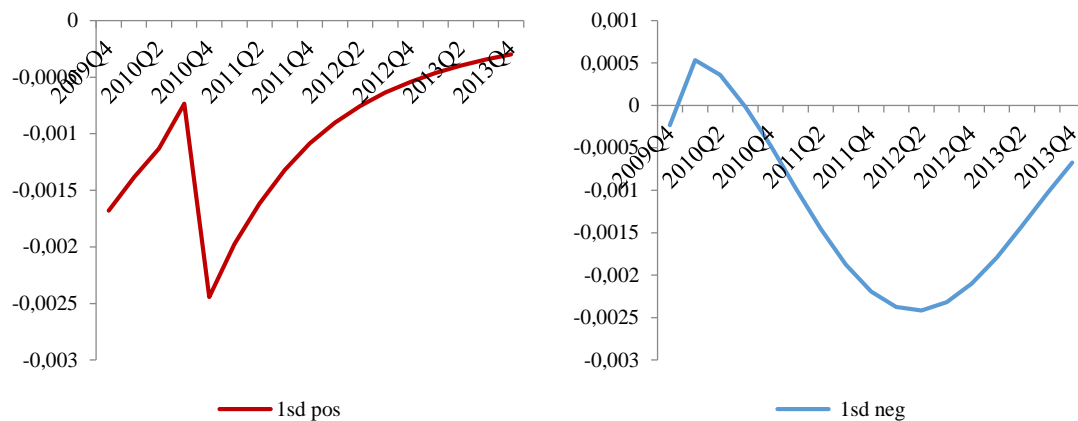
Graph 3 | Net taxes shock effect on output growth rate (Financial stability)



Focusing on the impact of a change in taxes, a positive shock leads to a small decrease in GDP in the first quarter that is followed by an increase in the GDP growth rate in the consequent quarters.

A decrease in net taxes causes an increase in output that after four quarter has almost no impact in the economy.

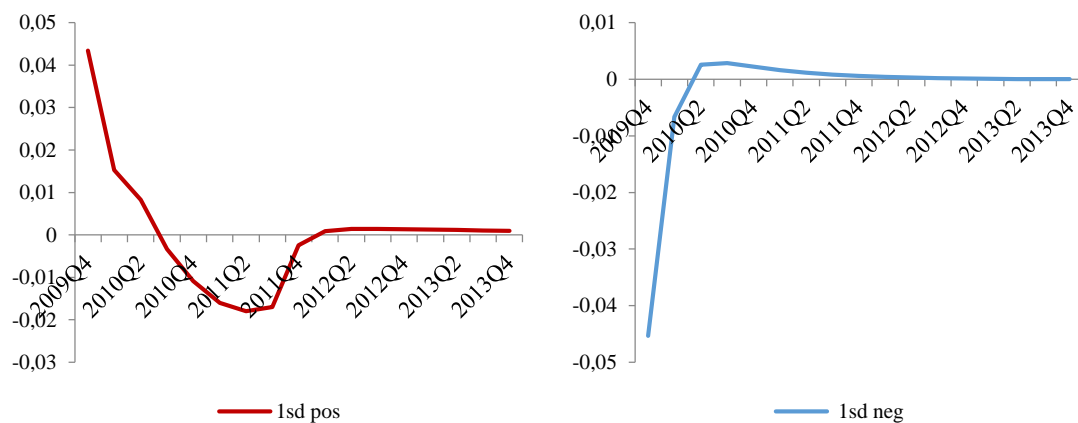
Graph 4 | Government spending shock effect on output growth rate (Financial stress)



In a situation of financial stress, a shock, at the third quarter of 2009, causes a very different behaviour than the same shock during a period of financial stability. A positive shock in expenditure causes a permanent decrease in output, which also has a much larger magnitude.

A negative government shock has a positive impact in output during the first year, but in the long run the GDP growth rate is negatively affected by the shock.

Graph 5 | Net taxes shock effect on output growth rate (Financial stress)



As for the impact of a shock in taxes, during a financial stress period, the initial output response to an increase in taxes is positive, but after 5 quarters the GDP starts to decrease and only in the last quarters it starts to, slight, increase again.

The equivalent negative shock in taxes causes the GDP growth to decrease, however the shock has a small long-run impact and has a slight positive impact in output before it dissipates.

The periods chosen for financial stress also corresponds to periods when the GDP growth rate, defined as the first difference of the logarithm of GDP, is smaller than zero. On the other end in the period choose for financial soundness the GDP growth rate is positive. When analysing the GIRF's it is important to have this fact in mind because even if the fiscal shock has a positive impact in the GDP growth rate it does not necessarily mean that the GDP, as a whole, is increasing and the growth rate can still be negative.

Two main results can be taken from the analysis of the response functions. The first is that, in a financial stability regime, an increase in taxes has a smaller impact in GDP than government spending shock, this result is consistent with the wide spread idea that families tend to smooth consumption over time, meaning that a decrease in their income (due to direct or indirect taxation) is likely to not affect so much the path of consumption in the overall economy, especially when the shock implemented is a one-time shock.

A decrease in taxes however has a much higher impact, meaning that the initial reaction to an income increase is very strong. The initial impact is large but the effect of the shock dissipates very quickly.

The second result is that the impact of a fiscal shock is higher in times when financial markets are in stress than in times of financial stability, meaning that during periods of crisis the economy is more sensible to fiscal policy changes accordingly.

The differences in the results due to a positive or negative shock arise because the financial market situation also reacts to the path of the other variables, so the GIRF's express the impact of a shock and successive regime changes.

Fiscal multipliers

There are two types of fiscal multipliers that can be computed using a VAR methodology, the impact multiplier (IM) and the cumulative multiplier (CM).

$$IM_t = \frac{\Delta Y_t}{\Delta Z_t}; CM_t = \frac{\sum_{i=0}^n \Delta Y_{t+i}}{\sum_{i=0}^n \Delta Z_{t+i}}$$

As can be seen the difference between them is that the impact multiplier only gives us the impact that a change in the fiscal variable (Z_t) has on output in the current period, whilst the cumulative multiplier gives us the impact over time, since it is the sum of all shocks.

These multipliers differ from the GIRFs previously computed since they are computed in a linear fashion, not accounting for the non-linearity in the model; however they are still useful to help to understand the size and direct impact that a fiscal shock has on output.

Table 2 | Regime dependent fiscal multipliers from a one standard deviation shock

	Stress Regime		Stability regime	
	1 s.d. government expenditure	1 s.d. net taxes shock	1 s.d. government expenditure	1 s.d. net taxes shock
Impact multiplier	-0.000197	0.002121	0.000098	-0.000388
Cumulative multiplier	-0.007601	0.031359	-0.000204	0.001864

As can be seen in table 2 the multipliers for a change in government expenditure are all negative, except for the impact multiplier under a financial stability regime. In addition the net tax multipliers under a stress regime are positive and the impact multipliers of a net tax shock under stability is negative.

In the long run a cumulative increase in government expenditure has a negative impact on GDP and a continuous increase in taxes has a positive effect on GDP. In addition the multipliers under a financial stress regime have a larger magnitude than the one computed under a financial soundness regime.

Conclusion

The purpose of this study is to measure the different impact of government fiscal policy during financial stress times and compare them with a situation of financial stability. For this a threshold VAR model was used, constructing a financial stress index (FSI) to be a measure of the financial conditions and serve as a threshold variable.

The distinction among regimes is relevant since macroeconomic variables and business cycles can be associated to financial shocks and overall conditions in financial markets, some examples are the 1929 crisis and the recent financial crisis.

Such distinction of market conditions is particular relevant nowadays due to the financial crisis in 2008 and the Portuguese government debt crisis and subsequent austerity package being implemented in Portugal.

Large government indebtedness that can cause a loss of confidence in the ability of the government to payback its debt and in turn cause disruptions in financial markets. Such periods are often associated with economic downturns, especially if the shock in financial markets is one with a large magnitude.

By studying the different impact of fiscal policy and fiscal multipliers we can take some conclusions that may help to understand the path of the fiscal consolidation and its impact on the economic activity.

It is important to note that by using a threshold VAR model it is possible to reflect some of the non-linearity in the data and we can also better understand the path of fiscal policy by analysing its impact on the GDP growth rate.

From the GIRF's computation we get that an increase in the government expenditure growth rate has a negative impact in the GDP growth rate, in the quarter after the shock.

An increase in taxes has a positive initial effect on GDP growth.

There are also two important conclusions that can be drawn from the analysis of the shocks, the first is that both types of fiscal shocks are stronger (larger impact on GDP) when the financial markets are in stress, meaning that the FSI value is above the 23.32 threshold. During financial stress times GDP seems to react more to shocks in the fiscal variables but the long run effect of a shock is also smaller.

The second conclusion that can be taken from the results is that tax shocks, in financial stability times, tend to have a smaller impact when compared to expenditure shocks, this happens because only temporary shocks are considered and individuals tend to smooth consumption over time, so the overall impact in a change in household income is likely have smaller impact on GDP than the impact of a change in government consumption.

All and all it is possible to verify that, indeed, fiscal policy has a different impact depending on the regime considered. Expenditure or revenue shocks have also an impact with different magnitudes and sizes and these two results have important implications to the path and size of fiscal policy in Portugal.

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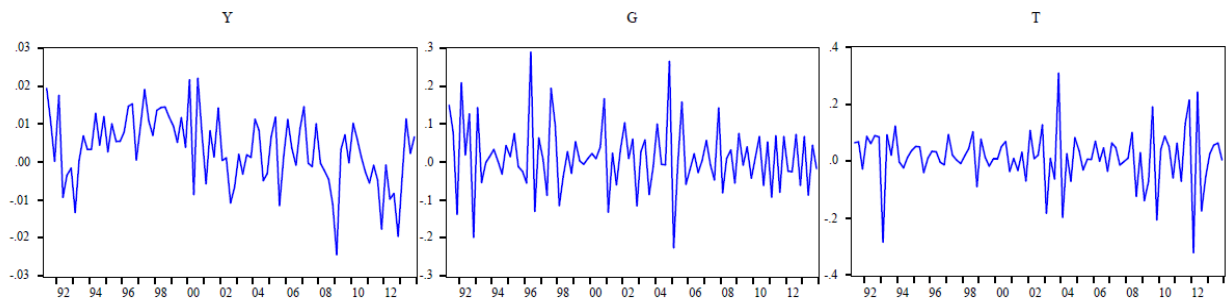
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Appendices

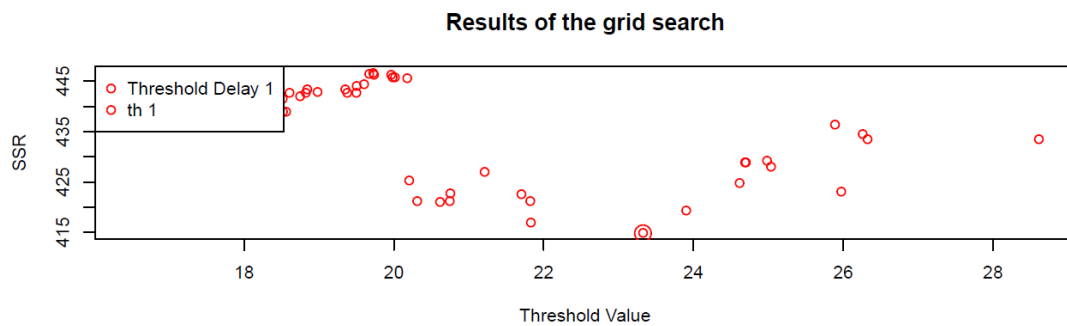
Appendix 1 | Descriptive statistics

	Government spending	Net taxes	GDP	FSI
Mean	0,013	0,014	0,003	22,139
Median	0,009	0,021	0,003	19,725
Maximum	0,290	0,309	0,022	41,188
Minimum	-0,225	-0,322	-0,024	11,365
Std. Dev.	0,089	0,096	0,009	6,799

Appendix 2 | Growth rate of GDP, government spending and net taxes



Appendix 3 | Grid search for optimal threshold value



Appendix 4 | Augmented Dickey- Fuller test

Null Hypothesis: Unit root (individual unit root process)

Series: GDP, GOV_EXP_SA, TAXES_SA, FSI

Date: 05/25/14 Time: 09:45

Sample: 1991Q1 2013Q4

Exogenous variables: Individual effects

Automatic selection of maximum lags

Automatic lag length selection based on SIC: 0 to 7

Total number of observations: 357

Cross-sections included: 4

Method	Statistic	Prob.**
ADF - Fisher Chi-square	8.11006	0.4228
ADF - Choi Z-stat	-0.23337	0.4077

** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.

Appendix 5 | Lag length criteria

VAR Lag Order Selection Criteria

Endogenous variables: Y G T FSI

Exogenous variables: C

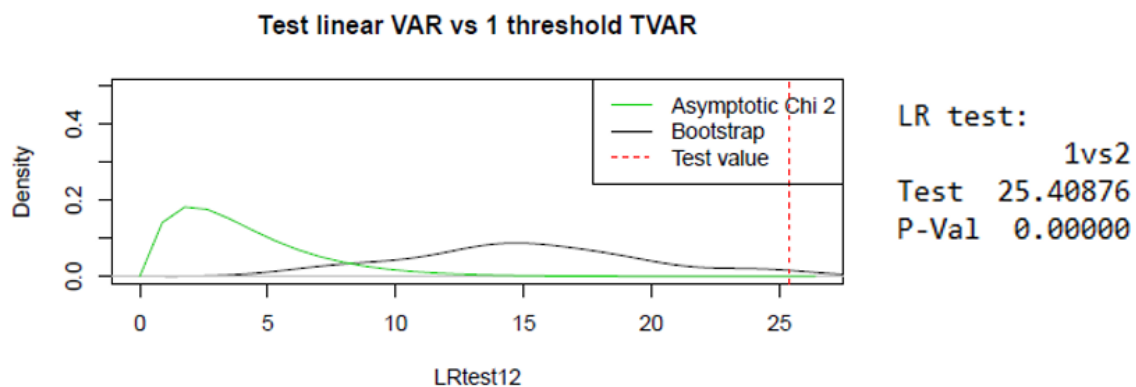
Sample: 1991Q1 2013Q4

Included observations: 83

Lag	LogL	LR	FPE	AIC	SC	HQ
0	509.1023	NA	6.08e-11	-12.17114	-12.05457	-12.12431
1	680.1096	321.4113	1.45e-12	-15.90626	-15.32340*	-15.67210
2	705.5232	45.31591	1.16e-12	-16.13309	-15.08395	-15.71161*
3	722.7928	29.12935	1.13e-12*	-16.16368*	-14.64826	-15.55487

* indicates lag order selected by the criterion

Appendix 6 | Likelihood Ratio test



Appendix 7 | TVAR model results

Financial Stress:

$$\begin{cases} y = -0.0006328 - 0.1772462y(-1) - 0.2781726g(-1) + 1.7761724t(-1) - 0.0008194s(-1) & \text{if } s(-1) \geq 23,32 \\ g = -0.0063576 - 0.0010154y(-1) + 1.0577814g(-1) + 0.1768178t(-1) - 0.0001053s(-1) & \text{if } s(-1) \geq 23,32 \\ t = 0.0050776 + 0.0393645y(-1) - 0.1053499g(-1) + 0.8592147t(-1) - 9.044e-05s(-1) & \text{if } s(-1) \geq 23,32 \\ s = -0.9386522 - 61.215508y(-1) - 277.10186g(-1) + 629.73961t(-1) + 0.7740735s(-1) & \text{if } s(-1) \geq 23,32 \end{cases}$$

Financial Soundness:

$$\begin{cases} y = 0.0137055 + 0.2759690y(-1) - 0.0180916g(-1) - 0.0250000t(-1) - 0.0005260s(-1) & \text{if } s(-1) < 23,32 \\ g = 0.0040806 + 0.1250742y(-1) + 0.8450243g(-1) - 0.0158016t(-1) - 0.0001329s(-1) & \text{if } s(-1) < 23,32 \\ t = 0.0226585 + 0.9711902y(-1) + 0.6177342g(-1) - 0.1534972t(-1) - 0.0012766s(-1) & \text{if } s(-1) < 23,32 \\ s = 5.5369203 - 14.264072y(-1) - 22.450986g(-1) - 16.099355t(-1) + 0.7367181s(-1) & \text{if } s(-1) < 23,32 \end{cases}$$

Appendix 8 | Financial stress index construction

1) Banking Sector

Banking sector β : covariance of the year-on-year percentage change of xxx banking sector equity index and the xxx overall stock market index, divided by the variance of the year-on-year percentage change of the overall stock market index. Source: STOXX Europe 600

Inverted term spread: Portuguese government short-term rate minus government long-term rate. Source: IMF

2) Securities Market

Stock decline: stock index_{t-1} minus stock index_t, then divided by the stock index_{t-1}. Source: OECD.

Time-varying stock volatility: GARCH(1,1) volatility of PSI20 monthly return. Source: OECD

3) Time-varying real effective exchange rate volatility: GARCH(1,1) volatility of real effective exchange rate monthly percent change. Source: IMF

4) Spread between Portuguese and German long term government rate. Source: IMF